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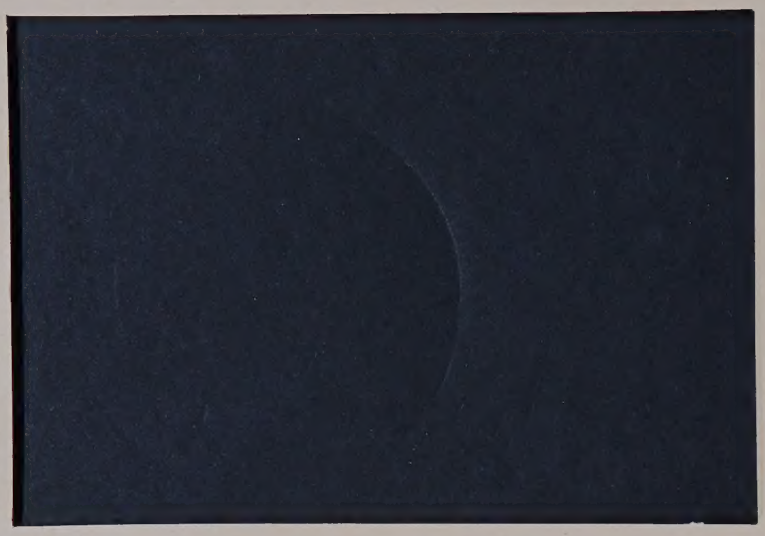
Canada Mortgage and Housing Corporation

Société canadienne d'hypothèques et de logement

A DESIGN ASSESSMENT OF SUPER-INSULATED DEMONSTRATION HOUSES BUILT IN THE KEEWATIN, NORTHWEST TERRITORIES AND PRELIMINARY DESIGN FOR A FOLLOW-ON UNIT



A DESIGN ASSESSMENT OF SUPER-INSULATED DEMONSTRATION HOUSES BUILT IN THE KEEWATIN, NORTHWEST TERRITORIES AND PRELIMINARY DESIGN FOR A FOLLOW-ON UNIT

A Research Study for Canada Mortgage and Housing Corporation
carried out by

Larsson Associates
Ottawa

Final Report
December 30, 1983

SECTION A

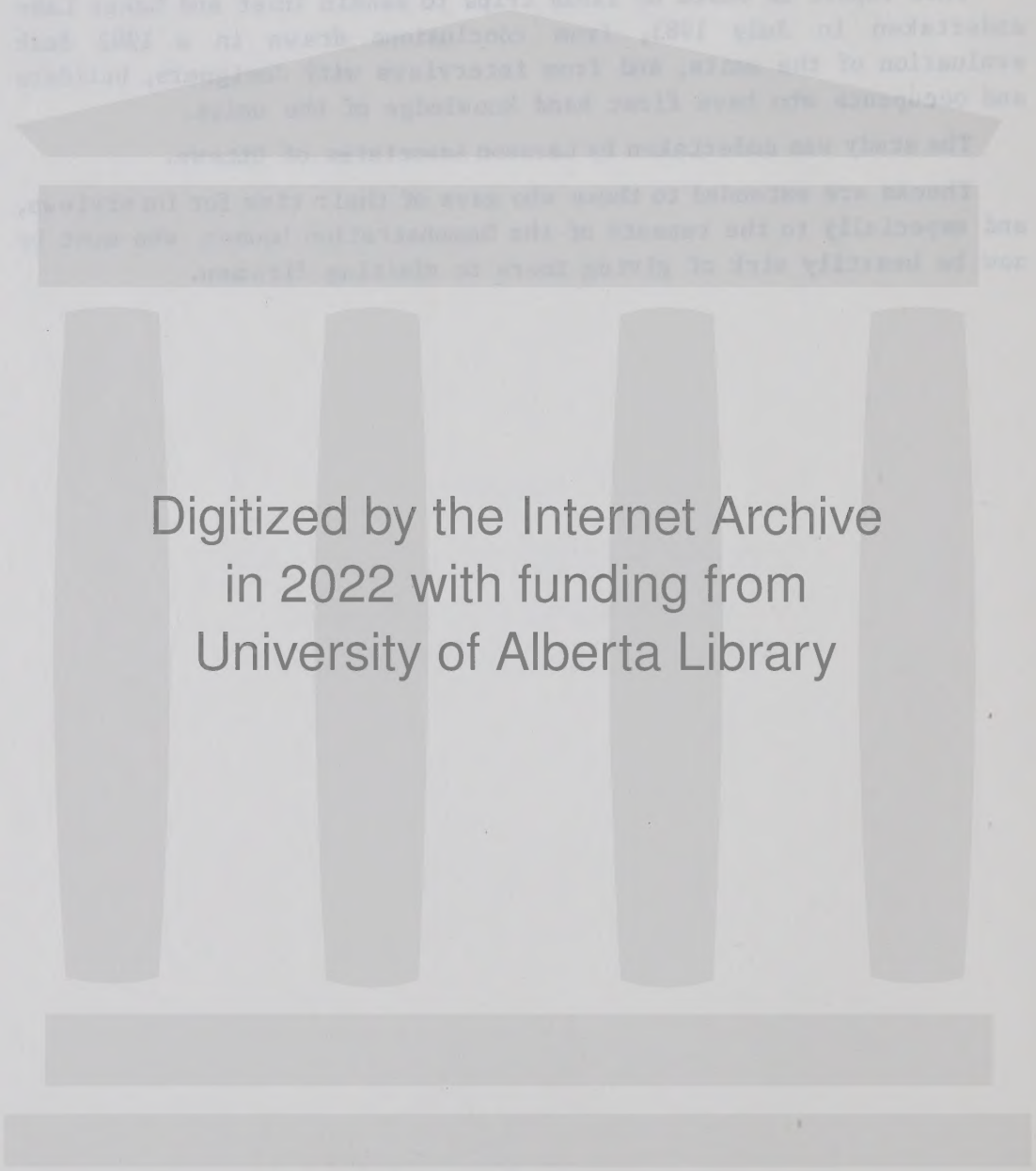
A DESIGN ASSESSMENT OF SUPER-INSULATED DEMONSTRATION HOUSES BUILT IN THE KEEWATIN, NORTHWEST TERRITORIES

ACKNOWLEDGEMENTS

This report is based on field trips to Rankin Inlet and Baker Lake undertaken in July 1983, from conclusions drawn in a 1982 desk evaluation of the units, and from interviews with designers, builders and occupants who have first hand knowledge of the units.

The study was undertaken by Larsson Associates of Ottawa.

Thanks are extended to those who gave of their time for interviews, and especially to the tenants of the Demonstration houses, who must by now be heartily sick of giving tours to visiting firemen.



INTRODUCTION

The Demonstration houses which form the subject of this study were designed and constructed under the authority of the Northwest Territories Housing Corporation (NWTHC), with financing provided by Canada Mortgage and Housing Corporation (CMHC). The underlying idea was to design, in conjunction with the Keewatin Federation and local associations, a house which would be suited to Northern ways of life, be highly energy efficient, and enjoy a measure of autonomy from community services in case of a temporary power failure. A total of seven houses were built in seven Keewatin communities during 1980/81, and it was intended from the start to undertake extensive monitoring and evaluation of the units, so that future designs can benefit from the lessons learned.

A firm of consulting engineers, Scanada Consultants Ltd., were retained in 1981-82 to measure the energy performance and fuel consumption of the units, using an equal number of other houses as control units. The control units chosen are known as "Woolfenden" units, and are in fact a relatively recent and thermally efficient single-storey design. The findings of the Scanada study became the focus of an internal CMHC evaluation which was undertaken in 1982. Despite some ambiguity in the data, both of these studies indicated that the two-storey Demonstration units provide a promising direction for northern housing in terms of their energy performance, structure and design features.

During 1983, indications of interest in the Demonstration units as a model for future production were expressed by the Inuit Non-Profit Housing Association (INPHC). It was decided by CMHC that additional and a somewhat broader assessment would help to clarify other aspects of the design, such as tenant acceptance, ease of construction and the functional performance of the facilities and spaces.

To achieve this aim, this study was structured so that the analysis could be translated into realizable functional specifications for a new unit. The new design has, however, been prepared according to the requirements of the draft Northern Residential Energy Standard, on the premise that this Standard represents good criteria for building in the North, and that it is likely to be in force when new units are to be produced.

A DESCRIPTION OF THE DEMONSTRATION UNIT

The specific problems which were addressed in the design included the harsh environment, permafrost, shipping difficulties, the problems of maintenance and the desirability of a higher degree of independence from the electric power utility. The dwelling was also intended to be more suited to the style of living of northern peoples, taking into account such factors as the pattern of extensive and long-term visiting between households, storage requirements for bulk foods, and storage and maintenance of hunting equipment, snowmobiles and the like.

The units are two-storey detached houses, a shape which results in l-ss exterior surface area than a bungalow of the same floor area. An unheated sunporch on the south side was intended to act as a buffer against cold winds, to provide storage space and to serve as an unheated vestibule. It was expected that the sunporch would also provide solar heat gain to the main part of the house during spring and fall months.

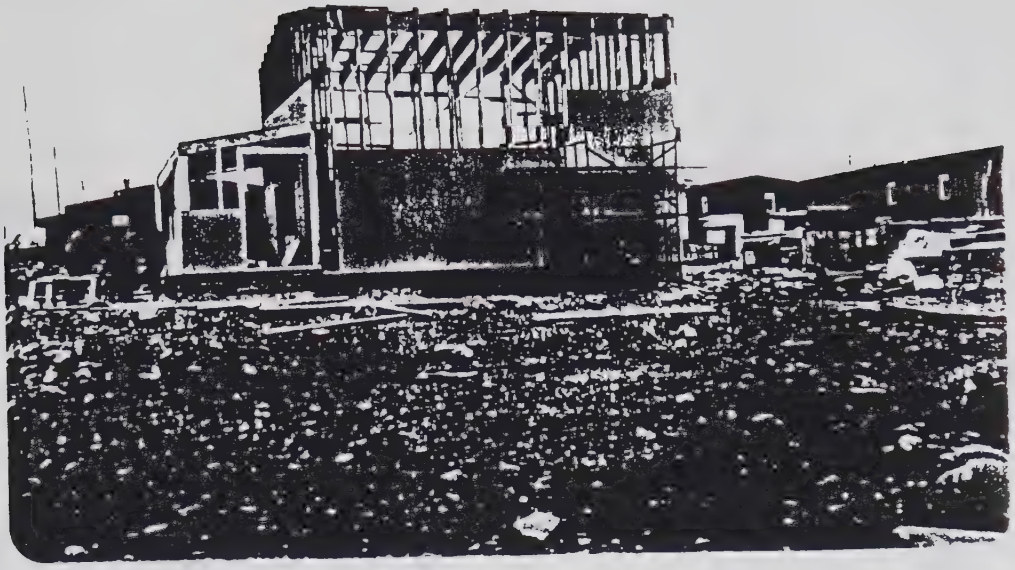
The heavily insulated walls, ceiling and floor of the Demonstration unit reflect current concerns of reducing heat losses. The natural consequence of a large amount of insulation was a thick wall, and this permitted the designers to establish rigid joints at floors and roof so that the usual problems caused by possible movement of the foundation could be reduced. The foundation itself is a continuous-span laminated beam system resting on a gravel pad.

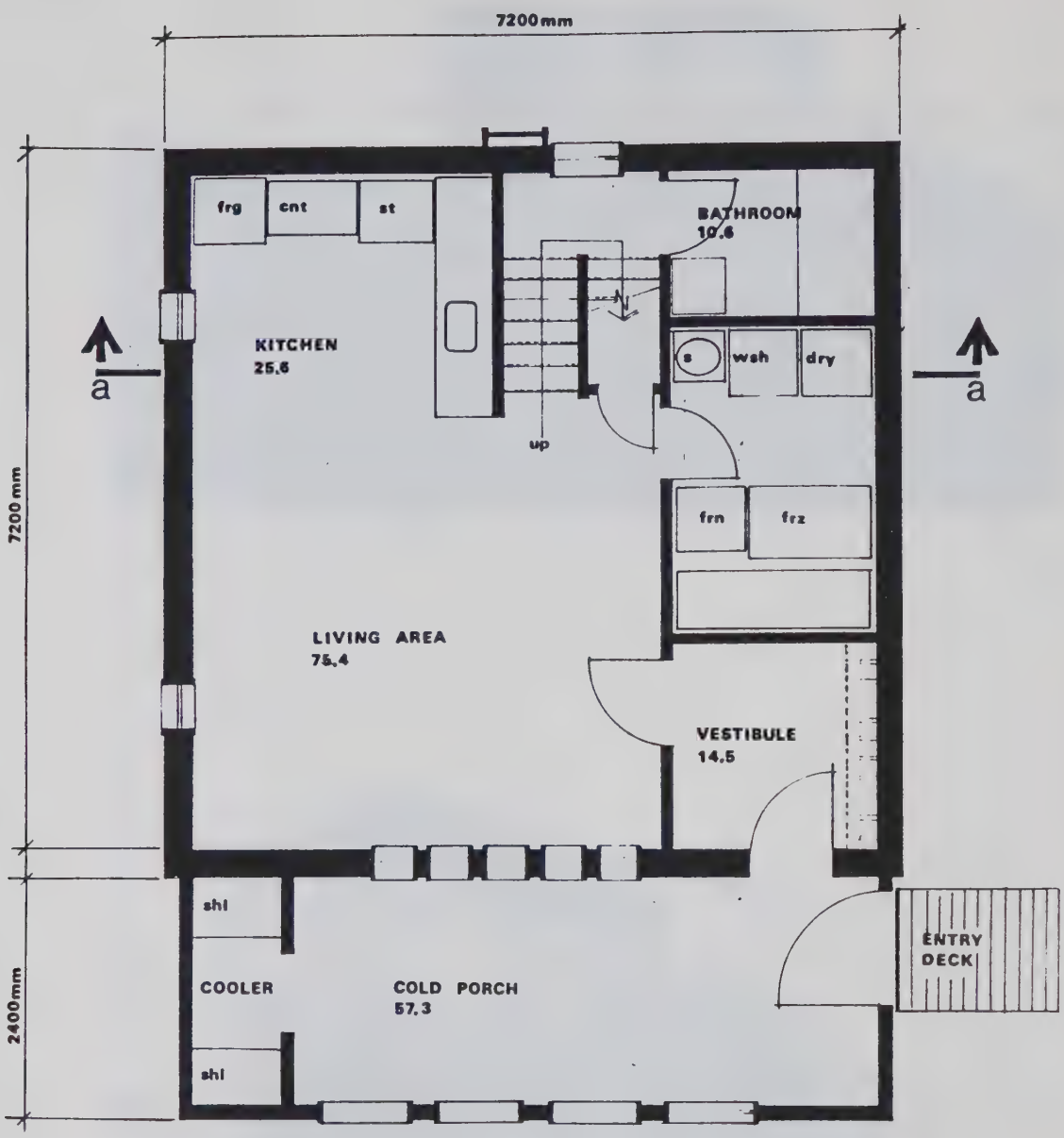
The careful installation of vapour barriers was a construction stage priority, to ensure that heat loss and moisture damage caused by the migration of airborne water vapour into the insulation and structure would be minimized.

The heating system, an oil-fired and gravity fed space heater, was intended to provide a measure of independence from the local power utility during power outages. Outages are not frequent, but when they do occur, they can cause costly damage to the house and extreme inconvenience to the residents. A manually controlled electric fan circulates the heated air from the top of the second floor, down through a duct to a second floor plenum, then out through the ground floor ceiling.

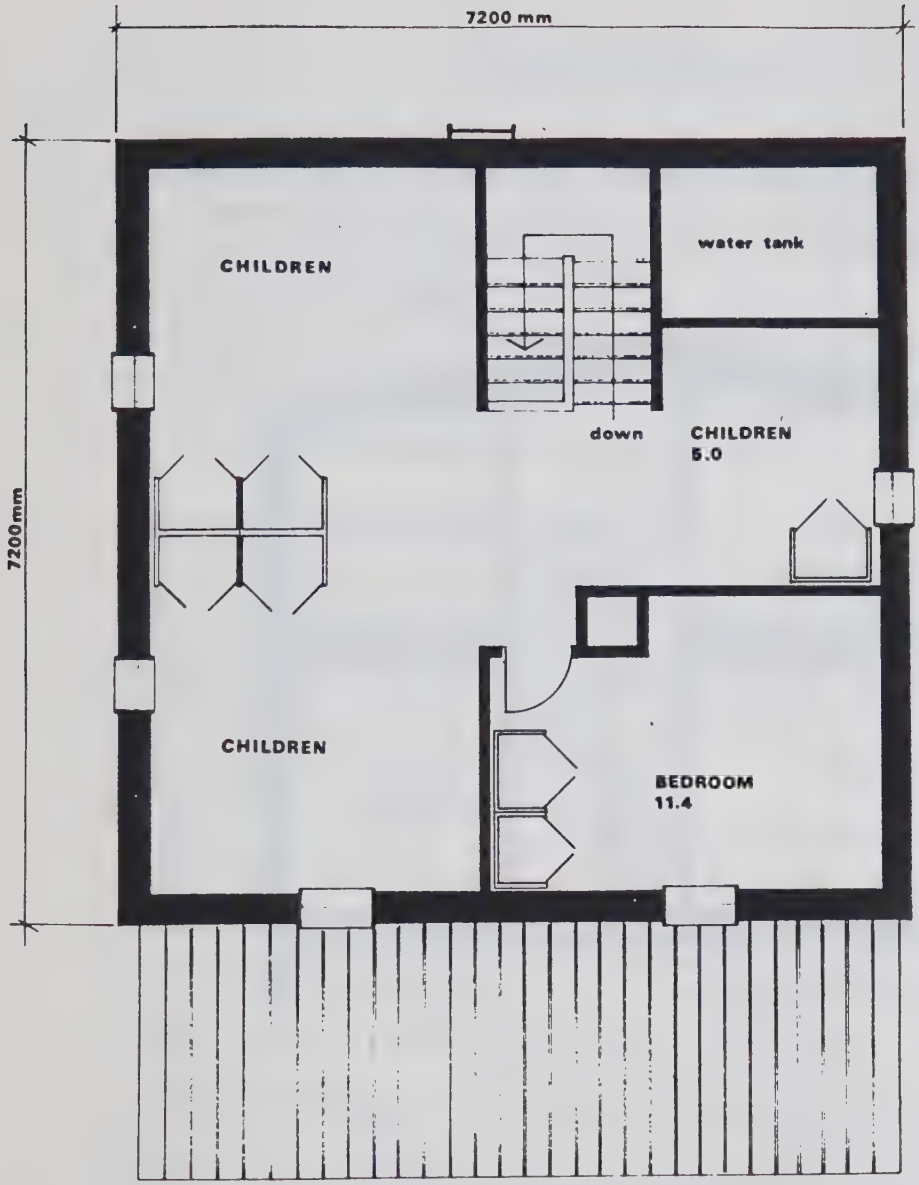
Hot water is provided by an oil-fired heater. Oil-fired units are less efficient than electrical heaters, but the very high cost of electrical power resulted in a lower projected operating cost for the oil-fired unit. Both cold and hot water systems are designed to operate on a gravity feed system, thereby ensuring operation during power outages.

A heat exchanger was installed to remove warm and stale air from the bathroom and kitchen, while heating the incoming cold fresh air.





DEMONSTRATION HOUSES KEEWATIN
1980
northwest territories housing corporation
ground floor

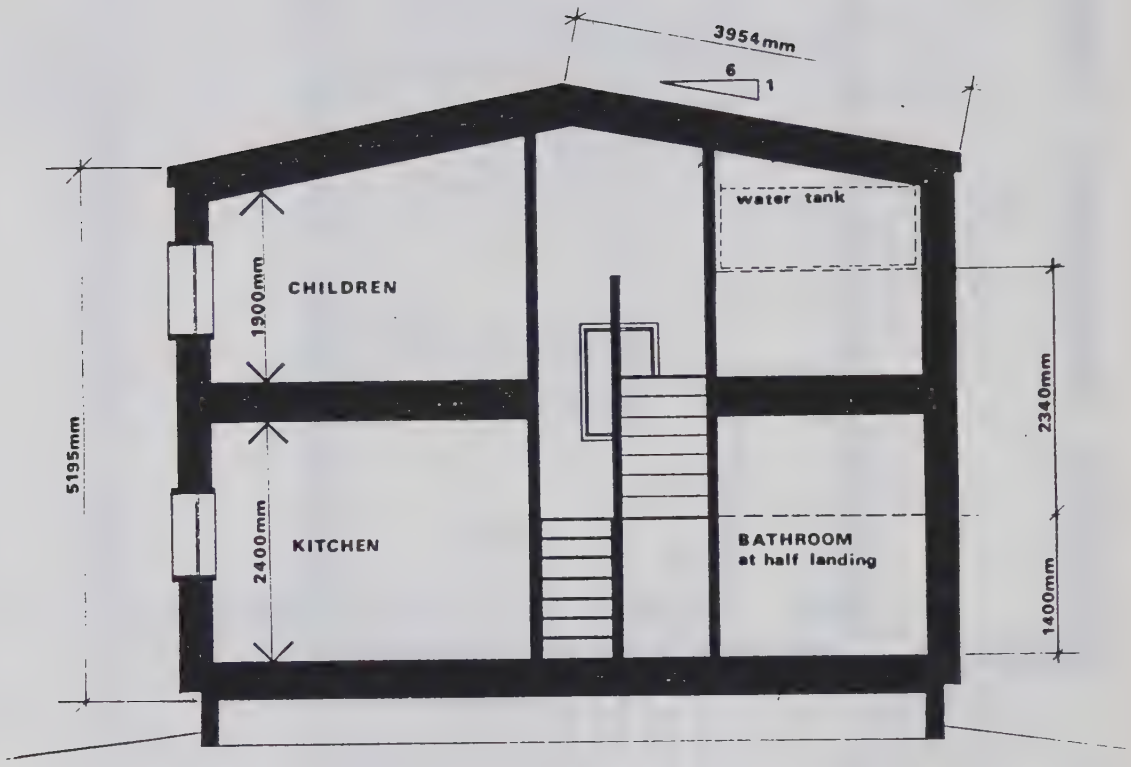


DEMONSTRATION HOUSES KEEWATIN

1980

northwest territories housing corporation

second floor



DEMONSTRATION HOUSES KEEWATIN
1980
northwest territories housing corporation

section a-a

SUMMARY OF FINDINGS

The findings are based on analysis of plans, observations and interviews. Field observations and interviews with tenants were carried out in Rankin Inlet and Baker Lake, and several designers and builders associated with the project were also interviewed (see Appendix 1 for records of interviews).

Although the interviews dealing with technical aspects of the units presented no surprises, there was a wide divergence in the views expressed by the two tenants on the adequacy of some of the functional features of the units, such as storage space .

Plan Function and Space Adequacy

The two-storey house form, while common in the South, is uncommon as a detached housing form in the North. Not only does it conserve energy through its shape, but there are other advantages which were only partially covered in the study. A space heater, for example, can work more efficiently in a two-storey unit than in a single-storey unit, because of the natural convection flow of warmed air to the second floor.

Another intrinsic advantage of the two-storey structure is its greater structural rigidity. Finally, the somewhat lower costs reported in the 1982 CMHC evaluation for the two-storey units relative to one-storey Woolfenden units is presumably a partial reflection of the reduction in envelope area - in that case, from 389 m^2 to 253 m^2, a saving of 35% for houses of the same floor area.

One possible drawback of two-storey units is the more elaborate measures for exits which must be taken to ensure the safety of second-floor occupants in case of a fire, but this should not present a major roadblock in the adoption of this housing type.

The reaction of the two tenants interviewed (in Rankin Inlet and in Baker lake) to the unit layout was positive, although such a small sample cannot be taken as being representative. As an example of this latter point, the interview notes in Appendix 1 indicate that there was a very different outlook on the adequacy of the storage facilities in the two units.

A general assessment, based on a blend of observation, plan analysis and interview material, is that the plan is generally efficient and suited to its purpose, with three major exceptions: the sunporch (see following section), the lack of partitions and doors between two bedroom areas, and the narrow staircase. The ambiguous feedback on the adequacy of internal storage space is paralleled on the exterior. For example, the Rankin tenants have added a lean-to shed to one end of the sunporch, whereas the larger family occupying the Baker Lake unit expressed no need for covered outdoor storage space.

The kitchens appear to work well, except for the curious placement of the refrigerator which makes access to it difficult. The open L arrangement has permitted a desirable degree of flexibility in its use. In the Baker Lake unit, the open portion is used for a dining table, but the Rankin Inlet tenants have added another counter/storage unit to provide a more traditional and enclosed space.

The location of freezer units appears to be somewhat unresolved. Originally, it was intended to place these in the equipment room, but the excessive temperatures forced a switch. In the Rankin unit it has been placed in the inner vestibule, whereas the Baker Lake tenants have placed theirs in the sunporch. Neither location seems ideal from a viewpoint of accessibility or aesthetics.

Performance of the Sunporch

Scanada pointed out that the sunporch, located on the south side of the Demonstration unit, appeared to have had little positive effect as an energy saving device, possibly because of the presence of grilles which admit cold outside air into the space for the heat exchanger intake.

Observations during the 1983 field trip strengthens doubts concerning the usefulness of the sunporch. In both units visited the floor area was used rather inefficiently for low-density storage of assorted bulk items, and the space is also reported to be very cold in the winter, and extremely hot during the summer.

A retrospective consideration of the position, wall construction and size of the sunporch may offer some clues as to the reasons for these mixed reviews. First, the fact that the sunporch is unheated, uninsulated on 5 of 6 faces, and has a relatively large glass area goes

far to explain the cold winter environment in the space - reportedly only some 10°C warmer than outside temperatures. Conversely, these factors, plus the lack of a heat sink or ventilation system, also explain the summer temperatures of up to 49°C reported by the Rankin Inlet tenant.

With regard to the functional use of the sunporch, it appears that its extreme temperature variation and minimal width preclude uses other than storage or workshop functions; but since the living room windows face directly into this space, it is difficult to exploit the storage or workshop function to the full without blocking the view from the living room.

Thermal Performance of the Envelope

The performance improvements due to the increased amounts of insulation and improved air tightness appear to be worthwhile from the perspective of energy conservation. The absence of detailed data on construction costs, however, makes a proper cost/benefit assessment impossible; and the suspected air leaks through the heat exchangers and/or space heaters have reduced the value of the Scanada field tests as indicators of the energy benefits of the envelope design.

Tenant interviews indicate that there may be a problem with the thermal performance of the floor construction. The Rankin Inlet household reports that carpets are needed to compensate for cold floors, and that freezing temperatures have been encountered in the under-stair storage area. This problem may be unique to the Rankin Inlet house, since the Baker Lake household made no similar observation. If it is a design problem, it is probably due to wind infiltration through the bottom-chord sheathing, which was not fastened, but merely dropped into place on the lower chords of the floor trusses. Other designers have solved this problem by adding a small top-side cavity which, even if uninsulated, provides a break in wind channels and protects the AV barrier.

Structure and Construction

The Demonstration house has several construction features which are noteworthy, including deep-section wall, floor and roof trusses, and continuous-span grade beams which create a hermetically sealed crawl space. The foundation design is an especially marked departure from the normal practice of encouraging air to flow between the insulated floor and the ground, to ensure that the active layer does not increase in depth.

Initial assessments indicate that that the goal of reducing differential structural movement has been met. Tests by Scanada indicate that appreciable settlement has occurred only in one corner of one Demonstration house, possibly caused by the loading of the water tank which is located in this area. A final assessment of the foundation design remains to be made, however. During the 1983 field trip it was noted that one corner of the gravel pad in the Baker Lake unit has deteriorated to the extent that the supposedly enclosed crawl space is now open to ambient temperatures - this may indicate a problem in achieving the sealed crawl space using conventional construction and grading methods. The ability of the insulated floor to prevent a long-term temperature rise in the sealed space is also open to question at the present time, since there have been no attempts to monitor the temperature variations in the crawl space.

Deane Lynch of Agrena Ltd., the builders of the Demonstration units, contributed several interesting points with respect to construction issues. It was found that the structure was difficult to erect, because of the two-storey wall trusses were difficult to handle without scaffolding (which would be expensive). Agrena also suggests that the floors were a weak point in the design, and that a tighter and stronger assembly could be obtained by the use of stressed-skin panels. Agrena strongly emphasizes the need for speedy erection, both as a method of reducing costs (because of prohibitive labour rates) and to improve the structural integrity of the product.

The inner side of the outside wall has a sandwich of plywood, vapour barrier and hardboard. The use of hardboard as a finish has been explained by some as being due to its superior capability to withstand differential movement, while others claim that it is used because drywall finishers are scarce. In any case, its function in the Demonstration unit is to serve as a finish and as a protection for the air-vapour barrier. Tenants interviewed noted the great difficulty experienced in hanging up pictures or other objects with adhesive fasteners on this surface, since the adhesive is not effective on the very smooth surface of the hardboard. It will not be surprising if future tenants drill through the hardboard, thereby puncturing the AV barrier. Regardless of the drawbacks of hardboard as a finish, it is suggested that the AV barrier should not be placed so close to the interior surface.

Space Heating

The oil-fired space heaters used in the Demonstration units were found to have an efficiency varying from only 40-70% compared to the 70-80% efficiency of the central heating oil-fired units normally used in Northern units. Scanada recommended the installation of an electric electric fan on the unit to improve its efficiency. If a power interruption were to occur, the fan would of course cease to operate, but the space heater would continue to function, albeit with reduced efficiency. The fan would also reduce the danger of an overheated chimney since the products of combustion would be cooled before entering the flue.

It was noted by several of the technically-oriented respondents that the unit has excess capacity for the small heating demands placed on it. Members of the Rankin Inlet household have found that many continuous adjustments are needed, both to prevent overheating of the flue and to maintain a comfortable temperature regime in the house.

Ventilation and Heat Exchanger

A reliable air exchange system is essential in a relatively air-tight dwelling such as the Demonstration unit. Air-to-air heat exchangers are in principle a desirable method of providing air exchange, for they can accomplish the twin objectives of providing fresh air and conserving energy. In this case, however, both tenants interviewed stressed the noisiness of the units; a fact which led one to turn off the unit at night and the other to keep it turned off. The units installed do not, however, constitute a fair test of the heat exchanger concept since they were not installed as designed. Scanada's site tests indicated, not surprisingly, that the units were very inefficient in operation. Models now coming onto the market should prove more satisfactory.

Water System

The idea of eliminating dependence upon electrical power was admirable. In practice, the gravity water feed resulted in less-than-adequate shower performance but this was probably because the position of the water tanks, directly over the bathroom ceiling, did not provide enough head for good pressure. A further problem is that the high-level location of the tank makes it difficult to fill with normal water-supply truck systems. A pressurized system has now been installed.

Although attempts were made to install a hot water heater without electric ignition, none could be found, and this will obviously create a problem during a power outage. It should be noted that although test results indicate that more energy was used to operate the oil-fired water heaters of the Demonstration units than the all-electric Woolfenden units, the significantly lower cost of oil for the same energy output makes this a worthwhile tradeoff.

Other Features

The oil-fired space heaters used were extremely inefficient, but with the addition of the circulating fan suggested by Scanada it may prove to be a form of space heating in two-storey houses which offers a high degree of independence from power outages. Another form of space heating which would be suitable for this application is a hydronic system, using a DHW heater as the heating mode.

The heat exchanger concept is a sensible alternative to windows for the ventilation of airtight houses in the North, and it is likely that units will soon be developed which will operate efficiently and quietly. The gravity-feed water system did not work properly as designed, but even if a pump is required for fully satisfactory operation, gravity feed can be a useful option during power outages. More work is obviously required to find or design an oil-fired hot water heater which does not require electric ignition and pump, but this also appears to be an achievable goal.

CONCLUSIONS

The following conclusions are based on analysis of the Scanada study, the 1982 CMHC mini-evaluation, an assessment of the contract documents, the 1983 field trip and interviews with technical personnel associated with the project.

Configuration

1. The two-storey configuration should be retained.

Internal Planning

2. The clear width of staircases should be increased to a minimum of 860 mm (2'-10").
3. All bedrooms should be separated by full partitions and doors.
4. The allocation of space to vestibule and storage functions appears, in the absence of more definite evidence, to be satisfactory.
5. The sunporch should be dealt with in one of two ways:

   a) If the porch is retained in its present South orientation, then measures should be taken to ensure adequate summer ventilation, a heat sink should be provided, and insulation should be placed in the envelope to moderate the winter temperatures, or

   b) the porch should be removed and equivalent space added to the North side of the house, where it can function as a windbreak and be more fully utilized as a storage and work area.
6. The porch failed in its intended function of providing space for equipment and vehicles, partially because of its raised floor. One solution is to provide a porch which is wholly or partially accessible at pad level; ie. with only walls and a roof provided. Another solution is to provide a free-standing shed on the site.

Structure and Construction

7. The air-vapour barrier should be better protected by placing it deeper into the wall structure - this implies using a double wall or standoff wall type. An alternative is a strapped wall truss system.
8. A weather barrier should be provided under the external sheathing, as the sheathing joints cannot be made tight enough to prevent wind infiltration.

9. Floors should be stressed-skin panels, with a top 2x3 insulation layer (which can also be used to run some services through).

10. Wall trusses should be only one floor high, to ease assembly problems.

11. The concept of four continuous-span grade beams appears sound, but it is not yet possible to determine if the sealed crawlspace is workable. Insulated box beams should be explored as an alternative to the solid beams, in order to reduce weight and to provide a better thermal break.

12. The use of hardboard as an interior finish should be discontinued. If the AV barrier is better protected and if differential settlement is minimized, then an interior finish can be provided with better appearance and/or ability to take attachments. Drywall or plywood panels or pine planking might form a suitable range to select from.

Mechanical Systems and Environmental Control

13. The oil space heaters should be abandoned in favour of a DHW water heater feeding a hydronic system. If one heater is used for both domestic hot water and the hydronic system, then a considerable excess capacity will be experienced during summer and shoulder seasons. Until suitable equipment is developed, a parallel system is probably the best solution. In areas where wood is available, an airtight wood stove can be used in the living area as a backup or alternative system. The use of the sunporch as a source of combustion air should in any case be discontinued, as it reduces the buffering action of this space.

14. The use of AAHE units should be abandoned until more satisfactory units are developed.

15. The location of the water supply tank on the upper floor should be retained, so that a backup gravity feed can be provided during outages. The filling system should be provided with a backflow preventer.

16. Fluorescent lights should not be installed in unheated areas.

17. The level of thermal insulation provided (RSI 7.04) appears quite adequate for comfort and efficiency.

APPENDIX 1

NOTES FROM FIELD TRIP TO THE KEEWATIN

NOTES ON CMHC DEMONSTRATION HOUSE 15/08/83

INTERVIEW WITH TENANT IN RANKIN INLET

General

The family (two adults, two children) is very pleased with the units and, generally speaking, had no complaints.

Plan Function & Space Adequacy

The family has two adult and two child members. The occupant reports a lack of storage space, and this was borne out by observation of overflowing closet, coathook, food storage and sunporch facilities. These conditions exist despite the fact that this unit has approximately 8 m^3 of extra storage space because of the absence of sewage and water holding tanks; and despite the construction of a add-on external shed, approximately 6 m^2 in area.

The problem may be explained by a number of factors. First, the family uses Sealift, which the occupants of the Baker Lake house do not. Secondly, the family members found that the moveable closet units, provided as dividers between the second floor children's sleeping spaces, functioned poorly because of inadequate height being provided for hanging clothes and because of poor craftsmanship. Finally, a variation in lifestyles - hoarders versus minimalists - may explain why the same space is adequate for some, and inadequate for others.

Hooks in inner vestibule are good, but occupant would like more, since several changes of outdoor clothing are logically kept here. A freezer has been located here, and the occupants have built shelves in this space.

The staircase is very narrow - 76 cm clear - and has caused problems in moving of items between floors.

Sunporch

During the winter, the porch is about 10 deg.C warmer than the exterior, but this still means temperatures of - 30 deg.C when the outside temperature is - 40 deg.C. During the summer, the occupant reports temperatures of up to 49 deg.C

The tenant feels that the main exterior door should be further away from the secondary front door. Her reasoning is that ice builds up on the outer door because of currents of warm moist air escaping when the secondary door is opened nearby.

Quality, Materials

Ceiling is panel type with strips to cover joints. Some strips have fallen off.

Stairs are built in softwood, and are already showing signs of wear.

Hardboard is used for wall finishes. This is considered by the occupant to be a poor material, since it is very difficult to hang up items.

Mechanical & Environmental Control

It is important to note that a full Utilidor system exists in Rankin Inlet. The spaces allocated in the Demonstration unit design for sewage and water holding tanks are therefore being used for storage purposes in this house. The sewage tank space, accessible from under the staircase, has been used for food storage by the tenant, but she has found that cans freeze in this location.

The fuel tank was originally located inside. It has fortunately been moved, since the smell of oil permeated the house.

The oil space heater is considered quite satisfactory, although this should be seen in the context of the fact that the adults are in the habit of making constant adjustments to the burning rate.

Rugs are required on the ground floor to maintain a comfortable surface temperature.

Fluorescent lights in the sunporch are inoperative during the winter, since the cold weather affects ballast operation.

Incandescent lights within the house are all wall mounted, with the switch on the light. The switch is inconveniently high for use by children - this implies that separate switches would be desirable.

The air-to-air heat exchanger is too noisy, and is not used.

The hot water heater is reported to be excellent, in terms of both reliability and recovery time.

INTERVIEW WITH LARRY WHITAKER

Mr. Whittaker, the manager of the Baker Lake Hotel, was the site supervisor for the Baker Lake unit. He was interviewed briefly in Rankin Inlet. His points:

1. Plans were metric, but materials are still mainly Imperial. This caused confusion on site and extra cost.

2. The placement of the oil tank inside the dwelling was a mistake. One objection is to the smell of oil which permeated the dwelling. More seriously, when the oil being delivered is very cold, it overflows the tank when heated to room temperature.

3. The freezer was meant to be placed next to the hot water heater. This was a poor idea because of the excessive heat generated by the DHW.

4. The oil-fired space heater overheats and is basically a primitive and inefficient heating system. A desirable system would be a top quality DHW unit used as a boiler for a hydronic system.

5. The metal roofing is a good idea for longevity and low maintenance.

6. Staircases are too narrow.

7. As a point of information, Mr. Whittaker stated that most estimates of construction costs cited by government authorities are very low, since they often do not include profit or design fees. He feels that current total turnkey costs are in the order of $ 110-120 per square foot, or $ 1180 to 1290 per square meter.

INTERVIEW WITH LYELL WIEBE

Mr. Wiebe is the housing maintenance in Baker Lake. He had the following points to make, some of which refer to broader issues than just the Demo unit.

1. Space heaters are oversized - smaller units are needed.

2. Water pressure was very poor in the original design (a gravity feed was used).

3. The VAT tile in the sunporch was unnecessary. If the intent was to bring equipment and machines into this space (ATV's etc.), then the floor should have been left as painted plywood. Also, VAT is very slippery in cold conditions.

4. A large shed would be a preferable way to store equipment and materials.

5. General point: foundations should be skirted, since this keeps the floor 5 to 10 deg.C warmer.

INTERVIEW WITH TENANT IN BAKER LAKE

General

The family is composed of 7 to 8 persons, with up to 10 or 11 during holidays. The house is reported to be very comfortable.

Plan Function & Space Adequacy

The overall space is adequate for the family. In view of the situation in the Rankin Inlet unit, the fact that the Baker Lake unit has some 8 m^3 less storage space, and given the large size of this household, it was surprising that storage facilities were reported to be adequate. The tenant did express a need for more clothes hooks, but in other respects, storage was reported to be adequate. Observation confirmed that all storage facilities seem to be uncrowded.

Storage facilities are used in the following way: the sunporch is used for trunks, the freezer and odd bulk storage (boxes etc.); the outside cold storage room is used for camping equipment and parkas, depending on the season, and the bulk food storage space is hardly used at all, since the family does not buy bulk supplies.

In this family, the moveable bedroom closet units were used, although the workmanship leaves something to be desired. The closets were, however, pushed to the outside walls, as it was considered that they did not provide enough privacy (because of low height) to function as room dividers. Several Canadian flags were instead serving the room divider function, but a strong preference was expressed for doors.

The stair treads (250 mm or 9.84") are considered too narrow for comfort. Upon checking, it was ascertained that the stair does not conform to Code requirements (Risers are 7.87").

Sunporch

The sunporch is not used for ATV's or snowmobiles, since this would be too smelly.

VAT tiles are lifting in the sunporch

Quality, Materials

Note that SE corner grade beam is open under beam, thereby opening the crawl space to ambient temperatures.

The extra ladder on the exterior is to provide access to the water tank fill pipe.

Mechanical & Environmental Control

The AAHE is too noisy, so it is used only during the day.

The water storage tank is considered too small.

INTERVIEW WITH DEANE LYNCH, AGRENA LTD.

Design Variants

Agrena has produced two variants, based on the Demo unit plan, but using Agrena's patented arch system.

Demo - Design Points

The sunporch does not seem to be a worthwhile design element, since there is very little insolation during the winter, and since there is too much during the summer. The only periods during which it is desirable is during fall and spring, and insolation during these periods can be handled with normal south-facing living room windows.

The slope on the sunporch was increased. Its South orientation could cause critical thaw-freeze cycles and a good slope for runoff is therefore needed. A minimum slope for metal roofing should be 2.5 or 3 to 12.

Stairs were too narrow to bring up materials.

The return fan system in the upstairs closet was a good idea and has been used in some subsequent projects.

The open trusses used for the 2nd floor structure are good, since services can be run through, but anchorage at the walls was a problem, because of the skimpy 2x3 members used on the wall trusses.

Metric

The use of metric added an estimated 10% to the cost. Agrena now designs in Imperial, then does an exact conversion to metric, which allows them to satisfy Federal requirements while obtaining components which are actually available.

Mechanical

All their mechanical/electrical components are exposed for ease of problem identification and repair.

The space heaters used overheat and should not be used. They are now going to be used as backup systems in the new NWTHC panel houses - standby generators would be cheaper and better.

It must be remembered that if the water storage tank is located in a high position, that the filling point must be even higher - this presents an access problem.

Shipping

Although some very long items are shipped - ex. laminated grade beams - the economical limit is about 16 feet.

Demo Structure

The full height wall trusses were difficult to erect, because of their flimsiness, the presence of winds and the difficulty of working without a platform. It would be much more sensible to use a normal platform frame system, one floor at a time.

The Demo wall structure includes the air/vapour barrier being sandwiched between a layer of drywall and hardboard. Agrena feels that the drywall layer is not necessary as a base for the AV layer.

Plywood forms the exterior finish and the windbracing. Battens are used at the joints, and these probably leak. Tyvec (a weather barrier) should be used as a backing.

The design of walls and foundations results in the corner wall trusses being essentially unsupported - this should not be repeated.

The floor is leaky, since the ten-test which holds up the insulation is just dropped between the bottom chords of the wall trusses. The lack of a precise fit here makes leaks inevitable. A better system would be the use of stressed-skin panels - these can be up to 24 feet long, at a depth of 8", and they are pre-insulated. The only remaining potential leak areas are the joints at 4 foot intervals, which are caulked. Agrena also suggests adding 2"x3" sleepers on top for another layer of insulation. A very important feature of stressed-skin panels is that they allow a gravel pad and a floor to be assembled in one day, which gives a good working platform for the rest of the work. This speed is crucial because of the very limited working time available when materials are delivered in August.

The wall, floor and roof trusses were prefabbed by Agrena, and are estimated by Agrena to cost 1/2 of Larsen trusses.

Grade beams intended to be field-fabricated, but were delivered as glue-laminated components at a considerable saving in time and money.

Interior Finishes

Hardboard and vinyl-covered drywall were extensively used because they withstand shipping better and because of problems of settlement. Agrena's adoption of a heavy-duty and overdesigned foundation system has reduced settlement and allows them now to use normal drywall.

INTERVIEW WITH CHRIS JALKOTZY, SOLARCTIC LTD.

Mr. Jalkotzy was the designer in the NWT Housing Corporation who established the requirements for the Demonstration unit.

Oil tank was located inside because they were told that in using a non elctric oil heater, without pump, that the oil would have to be warm to flow properly. This is obviously unneccessary since the oil tanks have been moved outside without any reported problems.

The AV was sandwiched between drywall and hardboard to reduce air leaks from damaged AV membrane.

The sunporch is necessary if the South is heavily glazed, since it provides a buffer against heat loss. It could, however, be squeezed to a narrower dimension while still retaining the same solar function (this comment was in response to field observation that the sunporch does not appear to have a clearly defined functional use, nor does the space seem to be heavily used for any particular function).

A general point re. gravel pads - note that it does not help to install the pad one year ahead, since the pad alone has different reflection/absorption characteristics from the pad + house.

General point re skirting: it helps to keep the floor warmer in winter, but also retains ice longer in summer and encourages rot.

SECTION B

PRELIMINARY DESIGN
FOR IMPROVED KEEWATIN DEMONSTRATION UNIT

MAIN DESIGN FEATURES

The design specifications which have been used to prepare the revised design are primarily based on the analysis carried out on the existing Demonstration units, but they also reflect the requirements of the new Northern Residential Energy Standard. This has resulted in a design which goes beyond addressing the flaws of the original design, as outlined in the analysis. The following points outline the main design features of the proposed units, while the Conclusions section should be consulted for supporting detail.

Configuration and Overall Design

1. The two-storey configuration, with bedrooms on the second floor and a bathroom on the stair landing, remains as in the original. The second floor differs from the original design, since a more steeply pitched roof creates low headroom at the eaves. This feature is will reduce operating costs because of reduced exposed surface areas, and will also make construction simpler and cheaper, because of reduced material requirements. The whole floor plan can, of course, be flipped, if local conditions warrant.

Internal Planning

2. The porch has been moved to the North side of the house, where it can function as a windbreak and be more fully utilized as a storage and work area. Part of the porch has been made accessible at pad level, with only walls and a roof provided, so that it can be readily usable for equipment and vehicles at minimum cost. The remainder functions as a cold vestibule, as in the original. It should be noted that both doors face South and are relatively sheltered from wind although snow drifting problems may be experienced in some locations.

3. The ground floor plan has been rotated so that the heavily used Kitchen-Dining area faces South, with the bathroom, stair and service rooms on the North side. The living room is less open to other spaces than in the original, and is provided with sliding doors so that it can be used for temporary guest accommodation.

4. The kitchen-dining room contains a summer door, suggested on the premise that a well designed vestibule for winter access will be cumbersome to use during summer, and will cut off easy communication between parents and children.

5. The service room on the ground floor is provided with an air lock at the entry, reflecting the requirement of the Northern Residential Energy

Standard (NRES) for isolation of service rooms. An external access closure is also proposed for ease of access to equipment.

6. Three bedrooms have been placed on the second floor. The provision of full walls and doors should reduce the problems pointed out in the analysis of the Demo unit.

Structure and Construction

7. The overall net size of the main house is 7135 mm square, which is slightly smaller than the Demonstration unit, and allows the use of maximum 24 x 24 feet for the framed platform; a size which carries with it economies in material dimensions.

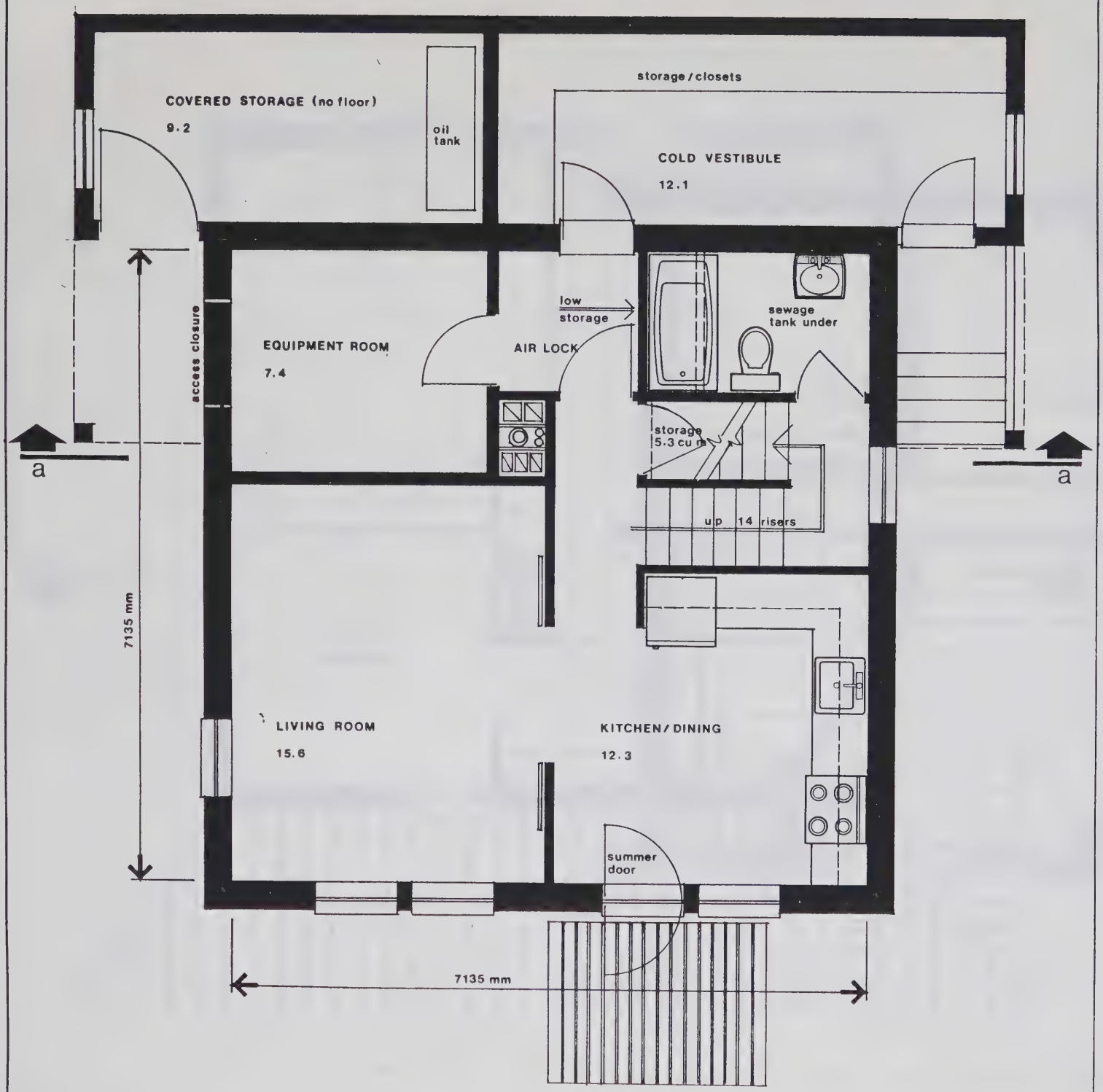
8. The ridge of the pitched roof runs on a North-South axis, and a bearing wall follows this line, allowing a cathedral ceiling configuration to be used without resorting to a heavy ridge beam. The slope of the roof has been calculated to allow the use of structural members with a maximum 16 foot length, and the bearing wall location permits 12 foot floor joists to be used - both of these factors should add considerably to both the material and shipping economies.

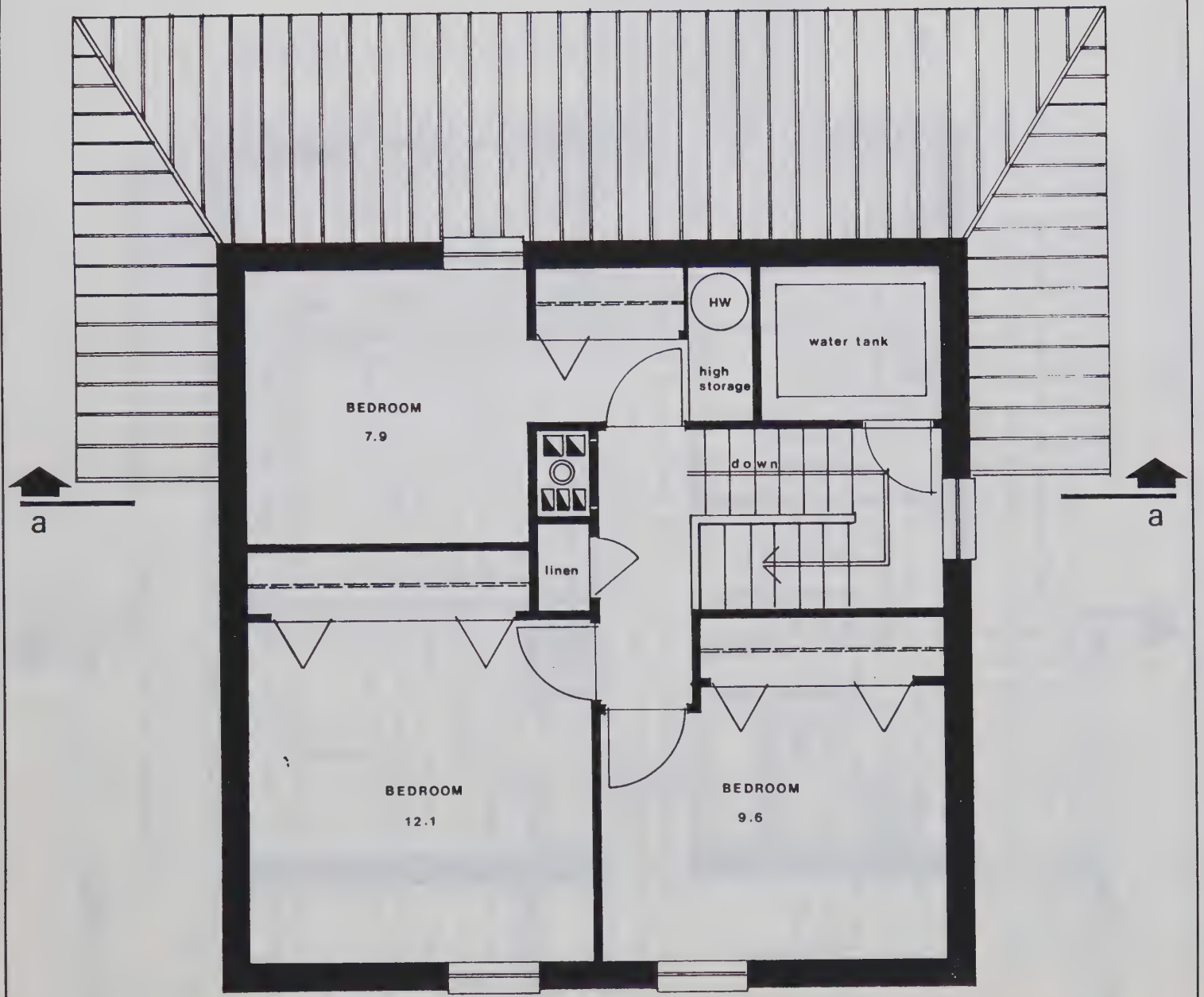
Mechanical Systems and Environmental Control

9. A central chimney duct allows the roof to be penetrated at only one location, to reduce the possibility of air and moisture migration into the roof. The chimney duct contains a flue, a stack and dry vent, ducts for room air supply and exhaust, room air recirculation and combustion air supply. The placement of these elements within the chimney will permit a limited and controllable amount of heat exchange. Cross-contamination of intakes and exhaust will be eliminated by placing intakes at low levels and the exhaust, flue and stack vent at high levels. Clearly, more work will be needed to ensure that this arrangement works, but there appear to be no conceptual impediments to its success. Access panels are provided on each floor for maintenance purposes.

10. Space heating will be provided by a hydronic system, with a boiler providing heat for both the space heating and domestic hot water systems. This system has been chosen partially because it allows the use of a single burner, which can operate more efficiently in a low-demand environment.

11. The use of an air-to-air heat exchanger is not assumed.


COVERED STORAGE (no floor)
9.2
oil tank
storage / closets
COLD VESTIBULE
12.1
access closure
EQUIPMENT ROOM
7.4
low storage
AIR LOCK
sewage tank under
storage 5.3 cu m
up 14 risers
a
a
7135 mm
LIVING ROOM
15.6
KITCHEN / DINING
12.3
summer door
7135 mm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7.9
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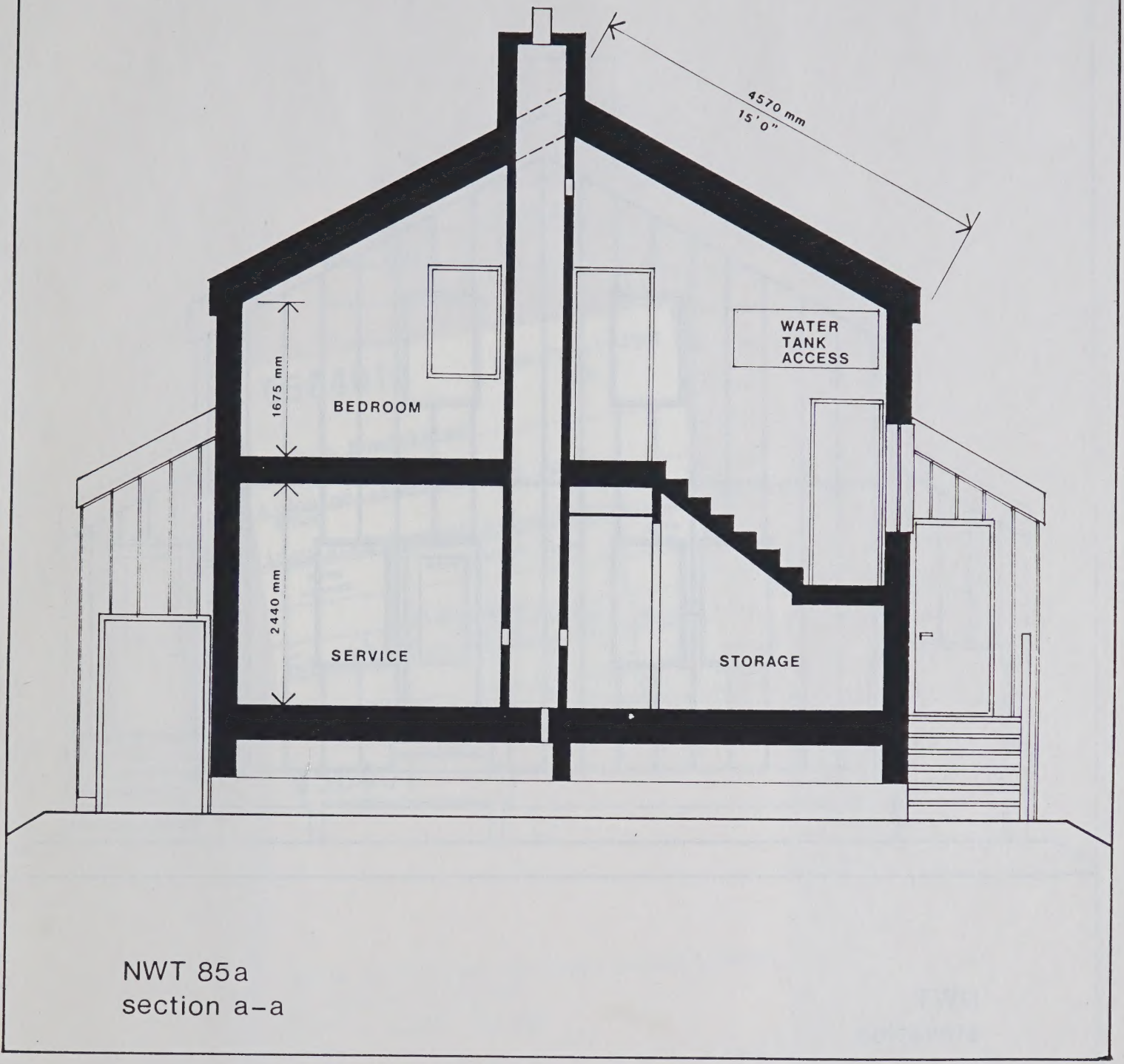

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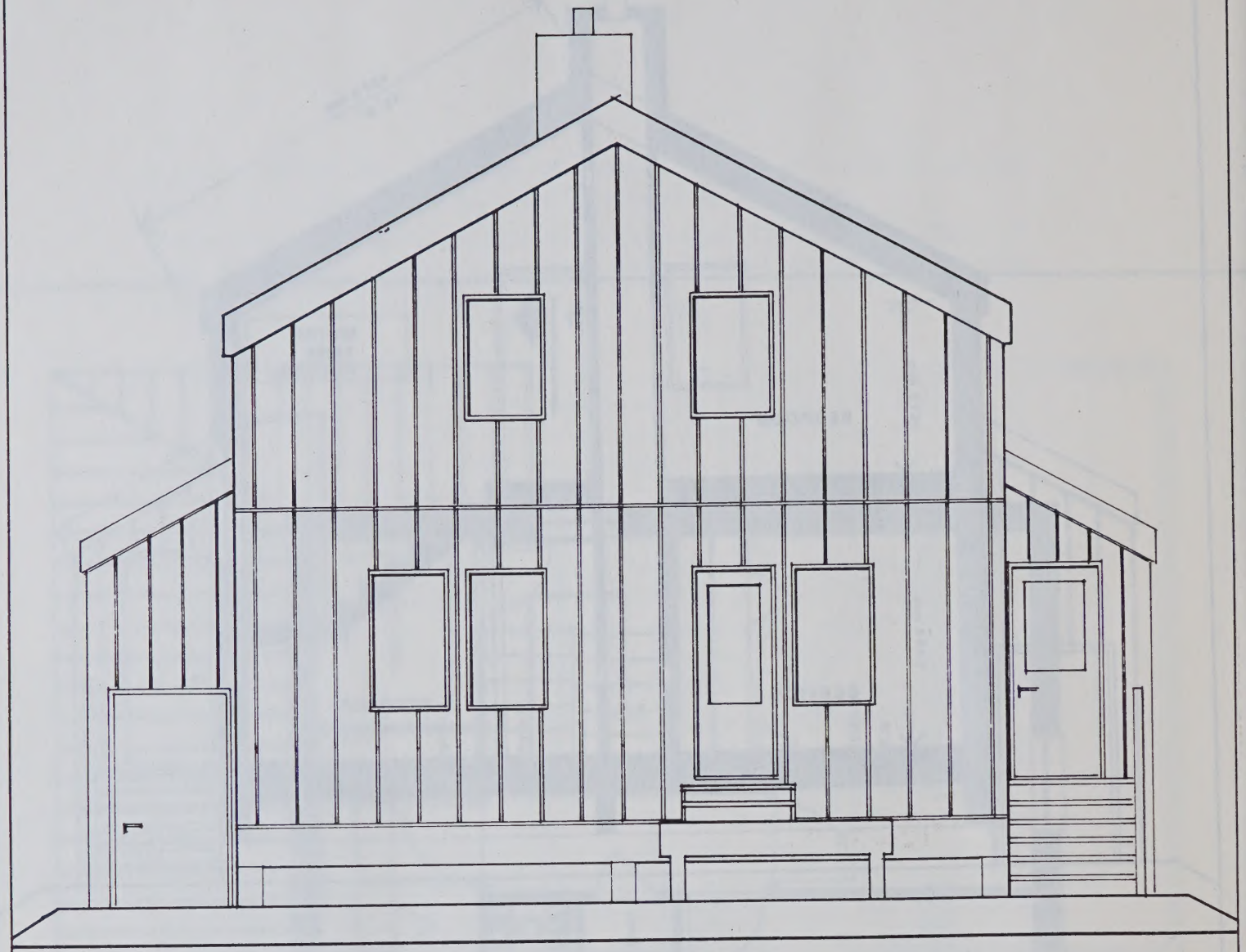
section a–a



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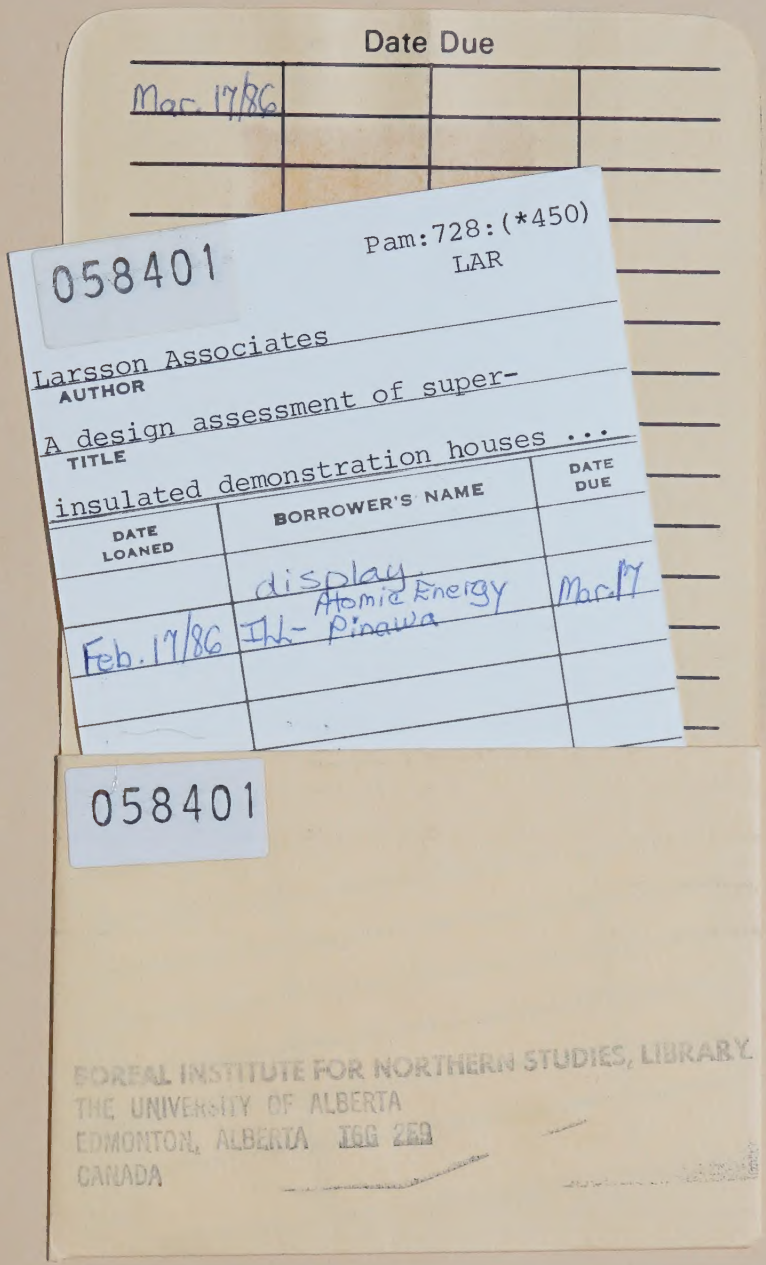
elevation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